

TERTIARY RED ALGAE FROM BORNEO



BY

J. HARLAN JOHNSON

(Professor, Department of Geology, Colorado School of Mines)

Pp. 255-280 ; 6 Plates ; 1 Text-figure

BULLETIN OF
THE BRITISH MUSEUM (NATURAL HISTORY)
GEOLOGY

Vol. 11 No. 6

LONDON: 1966

THE BULLETIN OF THE BRITISH MUSEUM
(NATURAL HISTORY), *instituted in 1949, is
issued in five series corresponding to the Departments
of the Museum, and an Historical series.*

*Parts will appear at irregular intervals as they become
ready. Volumes will contain about three or four
hundred pages, and will not necessarily be completed
within one calendar year.*

*In 1965 a separate supplementary series of longer
papers was instituted, numbered serially for each
Department.*

*This paper is Vol. II, No. 6 of the Geological
(Palaeontological) series. The abbreviated titles of
periodicals cited follow those of the World List of
Scientific Periodicals.*

© Trustees of the British Museum (Natural History) 1966

TRUSTEES OF
THE BRITISH MUSEUM (NATURAL HISTORY)

Issued 7 January, 1966

Price £1 10s.

TERTIARY RED ALGAE FROM BORNEO

By J. HARLAN JOHNSON

CONTENTS

	<i>Page</i>
I. ACKNOWLEDGMENTS	257
II. INTRODUCTION	257
III. LOCALITY AND AGE DATA	258
IV. SYSTEMATIC DESCRIPTIONS	261
Family CORALLINACEAE	261
Genus <i>Archaeolithothamnium</i>	261
<i>Lithothamnium</i>	266
<i>Mesophyllum</i>	267
<i>Lithophyllum</i>	269
<i>Lithoporella</i>	271
<i>Melobesia</i>	273
<i>Dermatolithon</i>	273
<i>Thaumatoporella</i>	273
<i>Corallina</i>	274
<i>Jania</i>	275
<i>Amphiroa</i>	276
<i>Subterraneanophyllum</i>	277
<i>Distichoplax</i>	277
Family SOLENOPORACEAE	278
Genus <i>Solenomeris</i>	278
Family SIPHONOCADACEAE	278
Genus <i>Pycnoporidium</i>	278
V. REFERENCES	279

SYNOPSIS

Forty-one species belonging to fifteen genera are described. Of these two species and one variety are considered to be new. The material comes from the Melinau Gorge and from the Upper Baram and Belukan Rivers, Northeast Sarawak, Borneo, Malaysia.

I. ACKNOWLEDGMENTS

I AM deeply indebted to Dr. C. G. Adams for his kindness in arranging for me to borrow this collection from the British Museum (Natural History) for study and for his assistance in supplying necessary data. Thanks are due the Colorado School of Mines who supplied the working space and laboratory facilities, and the Colorado School of Mines Foundation, Inc., for financing the project. Our secretary Mrs. Ruth Loomis typed the manuscript and read the proof.

II. INTRODUCTION

The coralline algae of the Paleocene are only slightly known. As of October 1963 only a single short paper had been published on them. In 1961 the author started a series of studies of the red calcareous algae from the Paleocene based on a series of collections obtained from oil companies, geological surveys, and museums. This paper, in so far as it deals with Paleocene algae from the Upper Baram area of Sarawak, represents the third of these studies. It does, however, also deal with

Miocene algae from the Upper Baram and with Upper Eocene (Tb), Oligocene (Tcd), and Lower Miocene (Lower and Upper Te) algae from the Melinau limestone in north-east Sarawak. This study is based on a collection of petrographic slides belonging to the British Museum (Natural History). They were made from a series of limestone samples collected by the Geological Survey of Sarawak, Sarawak Shell Oilfields Ltd., and by Dr. C. G. Adams who has also studied the foraminifera of these limestones and has supplied the data for determining the age of the samples.

III. LOCALITY AND AGE DATA

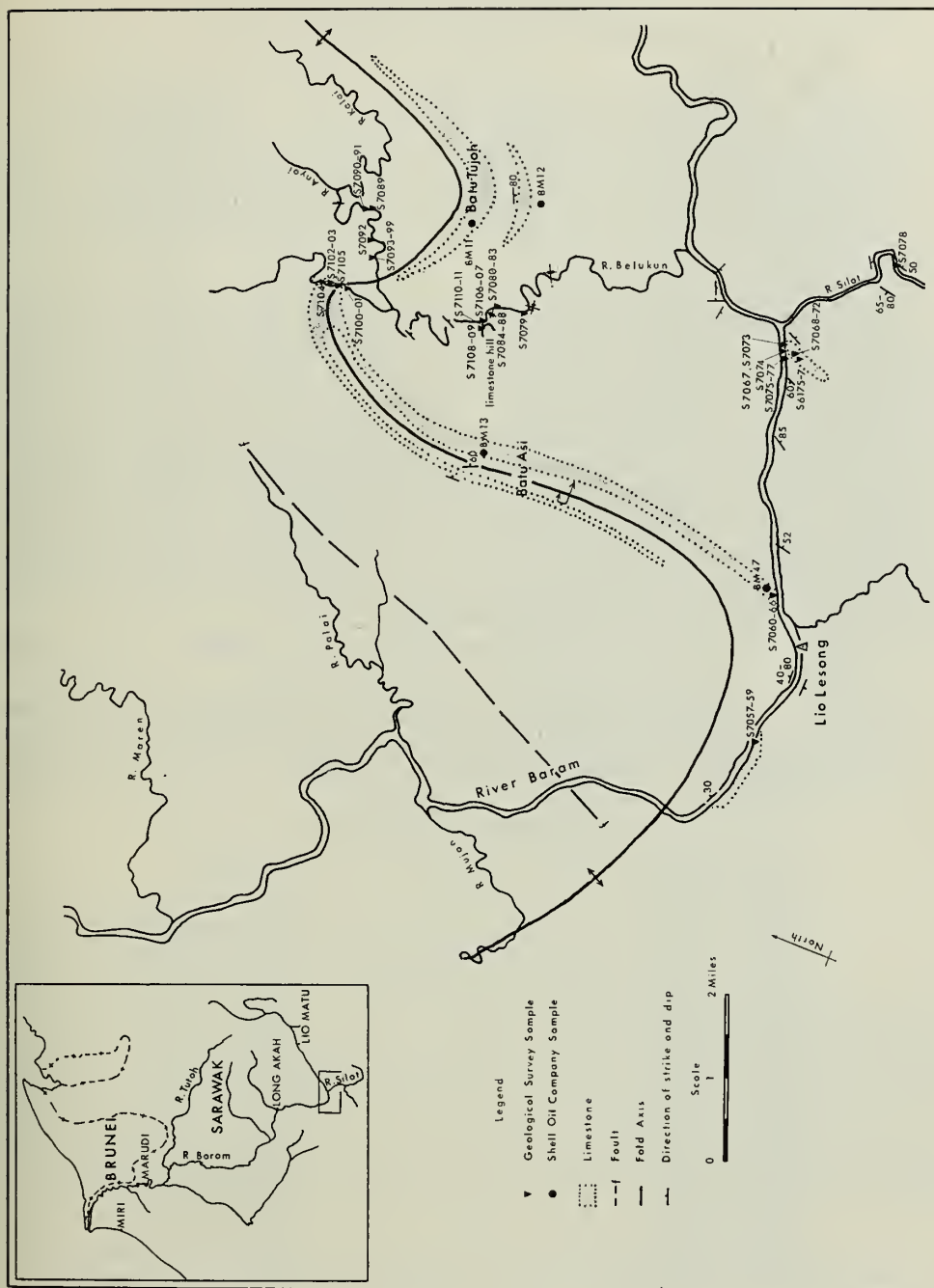
Limestones from the Upper Baram and Belukan Rivers

The locations of the samples from this area are shown on Text-fig. 1. The precise stratigraphical relationships of most samples are uncertain since the geological structure of the district is only known in outline. This is particularly true of the outcrops along the Belukan River where the tectonic picture appears to be fairly complex. The geological setting of the major limestones in the area has been briefly described by Liechti *et al.* (1960). All the Paleocene limestones in the area were assigned to the Kelalan Formation by Haile (1962). The same author considered that the associated Miocene limestones should be assigned to the Melinau Limestone Formation.

It should be noted that some of the samples dated as Paleocene are from conglomeratic limestones, and the possibility that the fossil content of these samples is reworked cannot be entirely ignored. All such samples are asterisked in the list below.

LIMESTONES FROM THE UPPER BARAM AND BELUKAN RIVERS

<i>Sample number</i>	<i>Age</i>
S-7058 (1 slide) . . .	Palaeocene . . . Baram River
S-7059 (2 slides) . . .	Palaeocene . . . Baram River
S-7063 (7 slides) . . .	Palaeocene . . . Baram River
S-7067 (1 slide) . . .	Palaeocene . . . Baram River
*S-7068 (2 slides) . . .	Palaeocene . . . Baram River
S-7070 (1 slide) . . .	Palaeocene . . . Baram River
S-7072 (1 slide) . . .	Palaeocene . . . Baram River
*S-7073 (2 slides) . . .	Palaeocene . . . Baram River
S-7075 (4 slides) . . .	Palaeocene . . . Baram River
S-7076 (1 slide) . . .	Palaeocene . . . Baram River
*S-7077 (5 slides) . . .	Palaeocene . . . Baram River
S-7080 (3 slides) . . .	Miocene (TeI-4) . . . Belukan River
S-7081 (2 slides) . . .	Miocene (TeI-4) . . . Belukan River
S-7082 (3 slides) . . .	Miocene (TeI-4) . . . Belukan River
S-7085 (1 slide) . . .	Miocene (TeI-4) . . . Belukan River
S-7087 (1 slide) . . .	Palaeocene . . . Belukan River
S-7095 (1 slide) . . .	Palaeocene . . . Kalai River
S-7111 (2 slides) . . .	Miocene (Te) . . . Belukan River



LIMESTONES FROM THE UPPER BARAM AND BELUKAN RIVERS (*contd.*)

<i>Sample number</i>	<i>Age</i>	
S-7109 (3 slides)	Miocene (Te)	Belukan River
*S-6175 (1 slide)	Palaeocene	Baram River
*S-6176 (1 slide)	Palaeocene	Baram River
*S-6177 (1 slide)	Palaeocene	Baram River
BM 47 (1 slide)	Palaeocene	Baram River
BM 13 (1 slide)	Palaeocene	Batu Asi ridge

The Melinau limestone

The slides studied are listed below with their age as determined from the foraminifera. Full information regarding the provenance of the samples from the Melinau limestone has been given by Adams (1965). It is sufficient to state here that this limestone has a maximum thickness of almost 7,000 feet, that its base is in the Upper Eocene (Tb), and that it includes a great thickness of Oligocene (Tc and Td) and Lower Miocene (Te 1-5) beds. Most of the Melinau samples referred to in this account come from the north face of the Melinau Gorge where a large number of samples (S-10000-S-10194) were collected in stratigraphical order from the base upwards. The remainder come from different parts of the outcrop. Examination of the foraminifera has shown that the main stratigraphical boundaries occur at about the following levels in the Melinau Gorge:

Tb/Tc . between S-10085 and S-10094; i.e., at least 1,850 feet above the base.

Tc/Td . between S-10152 and S-10153; i.e., about 3,290 feet above the base.

Td/Te . between S-10165 and S-10166; i.e., about 3,400 feet above the base.

The junction between Lower Te (Te 1-4) and Upper Te (Te 5) is not reached in the gorge.

MELINAU LIMESTONE

<i>Sample number</i>	<i>Age</i>
S-6610 (2 slides)	Oligocene (Tc)
S-6613 (3 slides)	Miocene (Te 1-4)
S-6614 (3 slides)	Miocene (Te 5)
S-6624 (2 slides)	Miocene (Te 5)
S-6921 (3 slides)	Oligocene (Tc)
S-6952 (3 slides)	Oligocene (Tc)
S-6970 (1 slide)	Miocene (Te 5)
S-6971 (1 slide)	Miocene (Te 5)
S-6972 (1 slide)	Miocene (Te 5)
S-6976 (1 slide)	Miocene (Te 5)
S-6977 (2 slides)	Miocene (Te 5)
S-6979 (1 slide)	Miocene (Te 5)
S-6620 (1 slide)	Oligocene (Te 1-4)
S-6623 (2 slides)	Oligocene (Te 1-4)

BRITISH MUSEUM SLIDES
GEOLOGICAL SURVEY—SARAWAK*Samples from the Melinau Gorge*

<i>Sample number</i>	<i>Age</i>	<i>Sample number</i>	<i>Age</i>
S-10006a (1 slide)	Eocene (Tb)	S-10145b (1 slide)	Oligocene (Tc)
S-10015b (1 slide)	Eocene (Tb)	S-10148b (1 slide)	Oligocene (Tc)
S-10021a (1 slide)	Eocene (Tb)	S-10149a (1 slide)	Oligocene (Tc)
S-10025a (1 slide)	Eocene (Tb)	S-10153c (6 slides)	Oligocene (Td)
S-10030a (1 slide)	Eocene (Tb)	S-10154f (2 slides)	Oligocene (Td)
S-10032a (1 slide)	Eocene (Tb)	S-10155b (1 slide)	Oligocene (Td)
S-10040a (1 slide)	Eocene (Tb)	S-10160b (3 slides)	Oligocene (Td)
S-10055a (2 slides)	Eocene (Tb)	S-10162a (1 slide)	Oligocene (Td)
S-10060b (1 slide)	Eocene (Tb)	S-10176b (1 slide)	Miocene (Te 1-4)
S-10061a (2 slides)	Eocene (Tb)	S-10177b (1 slide)	Miocene (Te 1-4)
S-10087b (1 slide)	? Eocene (?Tb)	S-10179a (1 slide)	Miocene (Te 1-4)
S-10096a (1 slide)	Oligocene (Tc)	S-10184a (1 slide)	Miocene (Te 1-4)
S-10100a (1 slide)	Oligocene (Tc)	S-10189a (1 slide)	Miocene (Te 1-4)
S-10101a (1 slide)	Oligocene (Tc)	S-10194b (1 slide)	Miocene (Te 1-4)
S-10109a (1 slide)	Oligocene (Tc)	S-10207b (1 slide)	Eocene (Tb)

South face of gorge

IV. SYSTEMATIC DESCRIPTIONS

Phylum RHODOPHYCOPHYTA Papenfuss 1946

Class RHODOPHYCEAE Ruprecht 1851

Order CRYPTONEMIALES Schmitz *in* Engler 1892

Family CORALLINACEAE (Lamouroux) Harvey 1849

Subfamily MELOBESIEAE

Genus *ARCHAEOLITHOTHAMNIUM* Rothpletz 1891*Archaeolithothamnium aschersoni* (Schwager)

(Pl. 1, figs. 3, 4)

1883 *Lithothamnium aschersoni* Schwager : 147, pl. 29, fig. 25.1891 *Lithothamnium aschersoni* (Schwager) Rothpletz : 316.1961 *Archaeolithothamnium aschersoni* (Schwager) Segonzac : 437.

DESCRIPTION. A crustose form, commonly with small mammillated protuberances. Hypothallus poorly developed or absent. Hypothallic cells measure $12-20\ \mu \times 8-12\ \mu$. The perithallus forms most of the crust. Tissue quite regular. Cell threads fairly prominent, cross partitions thinner, cells $9-19\ \mu \times 8-15\ \mu$. Sporangia ovoid, arranged in regular rows (layers), height $73-86\ \mu$, diameter $40-52\ \mu$.

REMARKS. This widespread species is one of the most abundantly represented in the Borneo collection.

SAMPLE NUMBER AND LOCALITY. S-7068, Upper Baram River.

AGE. Paleocene (the figured specimens occur in a conglomeratic limestone).

Archaeolithothamnium cf. *cyrenaicum* Raineri

(Pl. 1, fig. 5)

1923 *Archaeolithothamnium cyrenaicum* Raineri : 30, text-fig. 2.

DESCRIPTION. Thallus crustose with protuberances or short stubby branches. Perithallic tissue fairly regular with well defined cell "layers". At irregular intervals "layers" of very short cells are interlayered with the normal perithallic cells. Normal cells measure $14-30\ \mu \times 8-13\ \mu$. Sporangia in layers or lenses. They measure $38-45\ \mu \times 70-74\ \mu$. This is very close to, if not identical with, Raineri's species from the Miocene of Cyrenaica.

REMARKS. Represented in the Borneo collection by a single, oblique section.

SAMPLE NUMBER AND LOCALITY. S-10153, Melinau Gorge, north-east Sarawak.

AGE. Middle Oligocene (Td).

Archaeolithothamnium intermedium Raineri

(Pl. 1, fig. 6)

1923 *Archaeolithothamnium intermedium* Raineri : 29, text-fig. 1.

DESCRIPTION. Crustose with rounded protuberances. The tissue of the protuberances is quite regular with "layers" of cells. The cells measure $12-19\ \mu \times 8-15\ \mu$. Sporangia moderately to closely packed in regular layers. They measure $36-42\ \mu$ in diameter and $79-111\ \mu$ high.

REMARKS. This closely approximates Raineri's species. Represented in the Borneo collection by a single good specimen and a couple of fragments.

SAMPLE NUMBER AND LOCALITY. S-7111, Belukan River.

AGE. Lower Miocene (Lower Te).

Archaeolithothamnium lauensum Johnson & Ferris

(Pl. 1, fig. 1)

1950 *Archeolithothamnium lauensum* Johnson & Ferris : 11, pl. 1, figs. A, D.

DESCRIPTION. Thallus forms a fairly regular crust up to 9 mm. thick. Hypothallus of curved cell threads. Cells square or rectangular in section, measuring $8-17\ \mu \times 8-12\ \mu$. Perithallus compact, quite regular, with cells measuring $8-15\ \mu \times 8-11\ \mu$. Conceptacles large, commonly much higher than wide, ovoid, $95-108\ \mu$ in diameter and $120-205\ \mu$ high.

REMARKS. Represented by only a few specimens, mostly small fragments. They fit the description of *A. lauensum* in all respects.

SAMPLE NUMBER AND LOCALITY. S-7111, Belukan River.

AGE. Lower Miocene (Lower Te).

Archaeolithothamnium liberum Lemoine

1939 *Archaeolithothamnium liberum* Lemoine : 61, pl. 1, fig. 14, text-fig. 26.

DESCRIPTION. Thallus develops as thin crust from which protuberances may arise. Hypothallus consists of curved threads of cells. Cell size $7-28\ \mu \times 7-18\ \mu$. Perithallus fairly regular, cell size $8-17\ \mu \times 6-18\ \mu$.

REMARKS. Represented in the Borneo collection by several young infertile crusts.

SAMPLE NUMBER AND LOCALITY. S-7076, Upper Baram River.

AGE. Paleocene.

Archaeolithothamnium lugeoni Pfender

(Pl. 1, fig. 2)

1926 *Archaeolithothamnium lugeoni* Pfender : 324, pls. 8, 9.

1935 *Archaeolithothamnium lugeoni* Pfender ; Miranda : 280.

1936 *Archaeolithothamnium lugeoni* Pfender ; Rama Rao & Pia : 35, pl. 4.

1939 *Archaeolithothamnium lugeoni* Pfender ; Lemoine : 52-53.

DESCRIPTION. Thin crusts growing superimposed to form a thick mass. Hypothallus very thin or absent, difficult to distinguish and measure. Perithallic tissue fairly regular with suggestions of layers of cells, but the horizontal partitions not all continuous. Perithallic cells $11-16\ \mu \times 8-13\ \mu$. Sporangia long ovoid to nearly subspherical, dimensions $80-104\ \mu$ high and $57-58\ \mu$ in diameter.

REMARKS. Represented by only a few fragments in the collection studied.

SAMPLE NUMBER AND LOCALITY. S-7077, Upper Baram River, Sarawak.

AGE. Paleocene.

Archaeolithothamnium macrosporangium n. sp.

(Pl. 3, fig. 4)

DIAGNOSIS. Crustose, hypothallus thin, cells $16-36\ \mu \times 7-14\ \mu$; perithallus regular, cells $9-29\ \mu \times 7-13\ \mu$. Sporangia abundant and unusually long ($135-200\ \mu$).

HOLOTYPE. Slide V-51765.

SAMPLE NUMBER AND LOCALITY. S-6921, mouth of Tukuruk River, Melinau, north-east Sarawak.

AGE. Lower Oligocene (Tc).

DESCRIPTION. Thallus develops as a crust probably with protuberances or small mammelons on the upper surface. Several may grow superimposed. Hypothallus slightly to moderately developed consisting of curved cell threads. Cells measure $16-36\ \mu \times 7-14\ \mu$. Perithallus regular with the appearance of cell "layers" as well as cell threads. Both the horizontal and vertical partitions between the cells

are moderately thick. Cells measure $9-29\ \mu \times 7-13\ \mu$. Sporangia numerous and unusually large. Commonly they occur in layers or lenses, appearing as rows in vertical sections. Sporangia measure $117-124\ \mu$ in diameter and $144-200\ \mu$ high. Where closely packed they are long ovoid in shape. If loosely packed, they tend to be round ovoid to nearly spherical.

REMARKS. This species is characterized by the cell size, regular perithallic tissue, and unusually large, especially unusually long, sporangia. It belongs in the same general group as *A. nummuliticum* (Gümbel) Rothpletz, *A. saipanense* Johnson, and *A. lauensum* Johnson & Ferris. It differs from *A. nummuliticum* in having larger, especially longer, cells, better developed hypothallus, more regular perithallic tissue, and much larger sporangia. *A. saipanense* has smaller cells which are nearly cubic in the perithallic tissue, and smaller sporangia ($50-100\ \mu \times 70-140\ \mu$ against $117-124\ \mu \times 144-200\ \mu$). *A. lauensum* from the late Lower Miocene of Fiji is probably the nearest described species, but it has smaller, especially shorter cells, and narrower sporangia.

Archaeolithothamnium sarawakense n. sp.

(Pl. 2, fig. 5)

DIAGNOSIS. Thallus crustose, well developed hypothallus and perithallus. Cells of hypothallus $16-23\ \mu \times 9-14\ \mu$. Cells of perithallus $7-14\ \mu \times 5-11\ \mu$, tissue fairly regular. Sporangia regularly arranged, diameter $31-48\ \mu$, height $38-54\ \mu$.

HOLOTYPE. Slide V.51762.

SAMPLE NUMBER AND LOCALITY. S-7063, south-west end of Batu Asi limestone, Upper Baram River, Sarawak, Borneo.

AGE. Paleocene.

DESCRIPTION. Crustose. Hypothallus well developed, composed of curved threads of cells. Cells measure $16-23\ \mu$ long by $9-14\ \mu$ wide. Perithallic tissue fairly regular. Cells $7-14\ \mu \times 5-11\ \mu$. Sporangia subspherical, in regular rows, lenses, or short layers (appearing as short rows in vertical sections). Size $38-54\ \mu$ high, diameter $31-48\ \mu$.

REMARKS. The dimensions of the cells and the size and shape of the sporangia are the same as those of *A. oulianovi* Pfender. However, the present species has a fairly regular perithallic tissue, a well developed hypothallus and the sporangia regularly arranged in layers or lenses; while *A. oulianovi* is characterized by having a very irregular perithallic tissue, sporangia irregularly scattered throughout the tissue, and a poorly developed hypothallus. It resembles the late Cretaceous *A. brevium* Lemoine but has somewhat smaller cells and a more strongly developed hypothallus.

Archaeolithothamnium saipanense Johnson

(Pl. 2, fig. 1)

1957 *Archaeolithothamnium saipanense* Johnson : 220, pl. 38, figs. 1-4, 6.

DESCRIPTION. Thallus develops a thick crust with protuberances. Hypothallus thin, commonly consisting of only a few curved threads of cells. Cells measure $8-17\ \mu \times 7-14\ \mu$. Perithallic tissue regular, with regularly spaced horizontal and vertical cell walls. Cells $8-13\ \mu \times 6-13\ \mu$. Sporangia long elliptical, commonly closely packed in regular rows, and a single thallus may bear a number of successive layers. Sporangia measure $75-120\ \mu$ high and $38-55\ \mu$ wide.

REMARKS. Essentially the same as material described by the author from the Upper Eocene of Saipan. This species is very similar to *Archaeolithothamnium sociabile* Lemoine. The cells are essentially the same size. The main differences are in growth habit and sporangia. *A. sociabile* develops thin crusts. Normally a fertile crust bears only a single layer of sporangia and these are rather widely spaced. *A. saipanense* develops thick crusts with rounded protuberances. Fertile crusts may bear numerous successive layers of tightly packed sporangia. The sporangia are usually longer and narrower than those of *A. sociabile*.

SAMPLE NUMBER AND LOCALITY. S-10021, S-10149, S-10153; all from the north face of the Melinau Gorge, Sarawak.

AGE. Upper Eocene (Tb) to Middle Oligocene (Td). S-10021 (Tb), S-10149 (Tc), S-10153 (Td).

Archaeolithothamnium sociabile Lemoine

(Pl. 2, fig. 3)

1939 *Archaeolithothamnium sociabile* Lemoine : 53-54, text-figs. 16-17.1961 *Archaeolithothamnium* cf. *A. sociabile* Lemoine; Johnson : 919, pl. 267, figs. 3, 4.

DESCRIPTION. Crusts, commonly thin, may be superimposed. Hypothallus thin and may be difficult to recognize as commonly composed of only two or three horizontal or very slightly curved cell threads. Cells measure $8-24\ \mu \times 7-14\ \mu$, commonly $8-16\ \mu \times 7-11\ \mu$. Perithallic tissue regular with horizontal partitions more conspicuous than the vertical. Cells $7-22\ \mu \times 7-12\ \mu$, commonly $11-17\ \mu \times 7-12\ \mu$. Sporangia in regular rows (as seen in vertical section), commonly only a single row to a thallus. Sporangia $80-100\ \mu$ high and $35-65\ \mu$ wide.

REMARKS. Numerous specimens observed at one locality which very closely fit Lemoine's descriptions of the type material from the Upper Eocene and Oligocene of Algeria.

SAMPLE NUMBER AND LOCALITY. S-10153, north face of Melinau Gorge, north-east Sarawak.

AGE. Oligocene (Td).

Lithothamnium aggregatum Lemoine

1939 *Lithothamnium aggregatum* Lemoine : 66-67, pl. 1, fig. 12; pl. 3, figs. 3, 4, text-fig. 27.

DESCRIPTION. Thin crusts, commonly less than 600 μ thick, which may grow superimposed or interstratified with other species or other organisms. Hypothallus slightly developed, commonly around 100-125 μ thick, of curved cell threads. Cells measure 15-22 μ long and 9-13 μ wide. Perithallic tissue fairly regular, 300-600 μ thick, with cells 14-27 $\mu \times$ 8-13 μ . No conceptacles observed.

REMARKS. Several infertile specimens observed in the Borneo collection which fit Lemoine's description of the species from the Oligocene of Algeria.

SAMPLE NUMBER AND LOCALITY. S-10160, Melinau Gorge, north-east Sarawak.

AGE. Oligocene (Td).

Lithothamnium cantabricum Lemoine

(Pl. 2, fig. 2)

1934 *Lithothamnium cantabricum* Lemoine in Lemoine & Mengaud : 175, text-fig. 1.

1961 *Lithothamnium cantabricum* Lemoine ; Segonzac : 442.

DESCRIPTION. Thallus develops as an undulating crust 0.25 to 0.4 mm. thick. The hypothallus is well developed (0.14 to 0.17 mm. thick), with cells 13-24 μ long and 9-11 μ thick. Perithallus 0.11 to 0.17 mm. thick with cells 7-11 $\mu \times$ 8-11 μ .

REMARKS. Represented by a single specimen in the Borneo collection. It differs from the holotype only in having a better developed hypothallus.

SAMPLE NUMBER AND LOCALITY. S-7063, south-west end of Batu Asi limestone, Upper Baram River, Sarawak.

AGE. Paleocene.

Lithothamnium cf. *causicum* Maslov

(Pl. 2, fig. 4)

1956 *Lithothamnium causicum* Maslov : 116-117, pl. 33, fig. 2, text-fig. 46.

DESCRIPTION. Thallus develops short stubby branches. The branches consist mainly of a medullary area of arched "layers" of cells and a narrow marginal area. The central portion is composed of threads of cells 29-56 $\mu \times$ 12-17 μ . In the lower part of the branch, this central tissue is irregular with the cell threads branching frequently and the cross partitions between the cells irregularly spaced. Higher up the tissue becomes regular with cross partitions strong and regularly spaced, giving the suggestion of "layers" of cells. There are also suggestions of growth zones.

The marginal tissue is thin and fairly regular. Cells 14-17 $\mu \times$ 11-14 μ . No conceptacles present.

REMARKS. The cell dimensions and frequent branching of the cell threads in the lower central area agree with Maslov's species from the Danian of the Caucasus region. The upper portion (not described or illustrated by Maslov) may be more regular.

SAMPLE NUMBER AND LOCALITY. S-6177, Upper Baram River, Sarawak.

AGE. Paleocene.

Mesophyllum curtum Lemoine

(Pl. 3, fig. 3)

1939 *Mesophyllum curtum* Lemoine : 92, text-fig. 61.

DESCRIPTION. Long slender branches. Tissue somewhat irregular, the vertical cell threads commonly as pronounced as the curved horizontal "layers". Numerous growth zones but their boundaries not pronounced. Cells unusually small, $7-9\ \mu \times 8-10\ \mu$. Conceptacles $325-343\ \mu$ in diameter, $140-149\ \mu$ high.

REMARKS. This form has unusually small cells. In character of tissue and size of cells and conceptacles, it fits almost exactly Lemoine's type material. It differs only in having longer and more narrow branches.

SAMPLE NUMBER AND LOCALITY. S-10177, Melinau Gorge, Sarawak.

AGE. Lower Miocene (Lower Te).

Mesophyllum cf. *pfenderae* (Lemoine)

(Pl. 3, figs. 1, 2)

1928 *Lithophyllum pfenderae* Lemoine : 100, text-fig. 14.

1939 *Mesophyllum pfenderae* (Lemoine) Lemoine : 87.

1961 *Mesophyllum pfenderae* (Lemoine) ; Segonzac : 438-439, text-fig. 4.

DESCRIPTION. The plants develop short sinuous branches 1.0 to 1.3 mm. thick. Medullary hypothallus forms most of the branch. It is composed of arched layers of cells arranged in pronounced growth zones, 5 to 9 cell layers to a zone. Cells rectangular, $28-40\ \mu \times 9-15\ \mu$. Marginal perithallus commonly formed of 3 to 6 layers of cells which measure $13-40\ \mu \times 9-14\ \mu$. Conceptacle $352\ \mu \times 125\ \mu$.

REMARKS. The Borneo material closely resembles the descriptions given by Lemoine and by Segonzac. It differs in having somewhat longer hypothallic cells. The branches may be more sinuous. Unfortunately, neither Lemoine nor Segonzac illustrates the branches or gives any descriptions of them, beyond diameter and length measurements.

SAMPLE NUMBER AND LOCALITY. S-6175, Upper Baram River, Sarawak.

AGE. Paleocene.

Mesophyllum vaughanii (Howe) Lemoine

(Pl. 4, fig. 3 ; Pl. 5, fig. 5)

1918 *Lithothamnium vaughanii* Howe : 6-7, pls. 7, 8.1939 *Mesophyllum vaughanii* (Howe) Lemoine : 89, pl. 1, figs. 2, 8, 11, 15.1962 *Mesophyllum vaughanii* (Howe) ; Johnson : 157, pl. 3, figs. 1, 2.

DESCRIPTION. The plant starts as a basal crust from which develop irregular protuberances or long slender branches. Basal hypothallus of curved rows of cells. The branches are formed of numerous, irregularly disposed growth zones. These consist of "layers of cells", commonly quite regularly arranged. Cells of central part of growth zones of branches slightly longer than those of basal hypothallus. Conceptacles large, numerous, and multiple apertured.

TABLE I.—Dimensional data of *Mesophyllum vaughanii* (in μ)

Slide	Hypothallic Cells	Perithallic Cells	Conceptacles
S-10109a		11-21 \times 10-15?	475-528 \times 220
S-10148b	13-22 \times 8-13	13-20 \times 8-13	364-510 \times 144-176
S-10032a		14-21 \times 6-11	
S-10100a	27-32 \times 8-19	7-12 \times 9-12	
S-10032a		19-26 \times 8-14	
S-10087b		12-19 \times 8-13	448-589 \times 167-220
Range	13-32 \times 8-19	11-21(26) \times (6)8-15	364-589 \times 167-220

REMARKS. This is a widely distributed Upper Eocene-Lower Oligocene species. It is represented abundantly in the Borneo collection.

SAMPLE NUMBER AND LOCALITY. S-10032 (Tb), S-10087 (Tb or Tc), S-10100 (Tc), S-10109 (Tc), S-10100 (Tc), S-10148 (Tc), S-10153 (Td). Melinau Gorge, north-east Sarawak.

AGE. Upper Eocene (Tb) to Middle Oligocene (Td).

Mesophyllum vaughanii (Howe) var. *sarawakense* nov.

(Pl. 4, figs. 1, 6)

DIAGNOSIS. Strongly branching with thick medullary hypothallus and thin marginal perithallus. Medullary tissue regular with cells 15-40 $\mu \times$ 7-26 μ . Perithallic cells 9-18 $\mu \times$ 7-12 μ . Suggestions of marginal conceptacles.

HOLOTYPE. Slide V.51772.

SAMPLE NUMBER AND LOCALITY. S-10153 and 10154, north face of Melinau Gorge, north-east Sarawak.

AGE. Middle Oligocene (Td).

DESCRIPTION. Thallus starts as a rather thin crust from which develop long medium to thick branches. Branches consist of a strongly developed medullary hypothallus surrounded by a thin marginal perithallus. Growth zones strongly developed in some specimens, not so prominent in others. Branches 1.6-3.8 mm.

thick and more than 6.0 mm. long. Growth zones 8–12 layers thick. Medullary cells $15\text{--}40\ \mu \times 7\text{--}26\ \mu$, commonly $20\text{--}28\ \mu \times 10\text{--}17\ \mu$. Cells in regular "layers" with thick horizontal partitions and thin vertical partitions. Marginal perithallus thin, cells commonly $9\text{--}18\ \mu \times 7\text{--}12\ \mu$. Several specimens show suggestions of marginal conceptacles with diameters up to about 600 μ . However, they are badly overgrown and precise measurements cannot be made.

REMARKS. This species closely resembles the typical *Mesophyllum vaughanii* (Howe) Lemoine in general appearance and growth habits. It differs slightly but consistently in several respects: the medullary cells are longer but narrower, the medullary tissue is more regular without the frequent development of secondary hypothallia so characteristic of *M. vaughanii*, and while there are suggestions of alternating layers of longer and shorter cells in some areas or all of the medullary tissue, this is not so common as in *M. vaughanii* and there is less difference in the actual size of the cells in alternate layers.

This form occurs abundantly in samples S-10153 and 10154.

Lithophyllum besalotos Johnson

1962 *Lithophyllum besalotos* Johnson : 159, pl. 4, figs. 4, 5.

DESCRIPTION. Plant forms thin irregular crusts which may grow superimposed. Hypothallus thin but easily recognizable, of irregularly curved cell threads. Cells measure $14\text{--}25\ \mu \times 7\text{--}11\ \mu$. Perithallic cells wider than high with thick horizontal cell walls. Cells arranged in layers like bricks. Cells measure $9\text{--}14\ \mu \times 12\text{--}22\ \mu$. No conceptacles observed.

REMARKS. Represented by only a few poorly preserved specimens.

SAMPLE NUMBER AND LOCALITY. S-10162, Melinau Gorge, Sarawak.

AGE. Middle Oligocene (Td).

Lithophyllum capederi Lemoine

(Pl. 5, fig. 6)

1900 *Lithothamnium tenue* Capeder : 180, pl. 6, fig. 15.

1900 *Lithothamnium dentatum* Capeder : 178, pl. 6, fig. 7.

1926 *Lithophyllum capederi* Lemoine : 11, text-fig. 11.

DESCRIPTION. Thallus forms a thin crust. Hypothallus coaxial with exceptionally thick concentric partitions. Hypothallic cells $13\text{--}19\ \mu \times 8\text{--}11\ \mu$. Perithallic tissue regular, composed of small, square or rectangular cells $6\text{--}10\ \mu \times 4\text{--}9\ \mu$.

REMARKS. This species is characterized by a coaxial hypothallus with unusually thick cell walls and very small perithallic cells. In cell measurements it closely resembles *Lithophyllum johnsoni* Ishijima.

SAMPLE NUMBER AND LOCALITY. S-7080, Belukan River, Sarawak.

AGE. Lower Miocene (Te).

Lithophyllum densum Lemoine

(Pl. 5, fig. 8)

1934 *Lithophyllum densum* Lemoine : 282, text-fig. 14.1956 *Lithophyllum* aff. *L. densum* Lemoine ; Maslov : 117, pl. 34, figs. 1-4.

DESCRIPTION. Long straight cylindrical branches with diameters ranging from 0.9 to 1.1 mm. A medullary hypothallus with gently arched layers of cells attains a diameter of 0.7 to 0.8 mm., with cells 25-40 μ long and 8-15 μ wide. The marginal perithallus is 88-180 μ thick, with cells 13-16 μ long and 7-12 μ wide.

REMARKS. This species is characterized by the long straight branches, thick medullary hypothallus with gently arched layers, and the long narrow hypothallic cells. The cells of the Borneo specimens are appreciably longer than those in the holotype of Mid-Eocene age, and slightly longer than Maslov's early Paleocene material. The other dimensions are the same.

SAMPLE NUMBER AND LOCALITY. S-6177, Upper Baram River, Sarawak.

AGE. Paleocene.

Lithophyllum dubium Lemoine1934 *Lithophyllum dubium* Lemoine : 282, text-fig. 13.1961 *Lithophyllum dubium* Lemoine ; Segonzac : 443, text-fig. 9.

DESCRIPTION. Thallus thin, crustose. Several may grow superimposed. Hypothallus about 200 μ thick with cells 17-25 $\mu \times$ 7-12 μ . Perithallus regular, up to 300 μ thick, with cells 15-17 $\mu \times$ 11-15 μ .

REMARKS. Represented by several infertile specimens.

SAMPLE NUMBER AND LOCALITY. S-7073, Upper Baram River, Sarawak.

AGE. Paleocene.

Lithophyllum cf. *obliquum* Lemoine

(Pl. 4, fig. 5)

1930 *Lithophyllum obliquum* Lemoine : 266, text-figs. 1, 2.1939 *Lithophyllum* cf. *L. obliquum* Lemoine ; Lemoine : 97, 98, text-fig. 64.

DESCRIPTION. Crustose, 0.4-0.55 mm. thick. Hypothallus 130-155 μ thick, poorly coaxial, "layers" only slightly curved, almost oblique with thick walls. Cells 20-25 $\mu \times$ 6-14 μ . Perithallus 350-450 μ thick with well defined "layers" of cells. Cells measure 8-12 $\mu \times$ 8-14 μ .

REMARKS. The general structure suggests *L. obliquum* Lemoine and the cells are about the same size. The main difference is a greater development of perithallic tissue. It is similar to *Lithophyllum* cf. *obliquum* Lemoine from Algeria.

SAMPLE NUMBER AND LOCALITY. S-7081, Belukan River, Sarawak.

AGE. Lower Miocene (Te).

Lithophyllum cf. *ovatum* (Capeder)

- 1900 *Lithothamnium ovatum* Capeder : 177, pl. 6, figs. 5a, b.
 1926 *Lithophyllum ovatum* (Capeder) Lemoine : 245-246, text-fig. 3.
 1932 *Lithophyllum ovatum* (Capeder) ; Airoidi : 70, pl. 10.
 1957 *Lithophyllum ovatum* (Capeder) ; Johnson : 228, pl. 45, figs. 4, 8.

DESCRIPTION. Thallus crustose with a well developed hypothallus and perithallus. Hypothallus 90-250 μ thick, poorly coaxial. Cells 11-22 $\mu \times$ 12-16 μ . Perithallus 100-250 μ thick with cells in slightly irregular "layers". Cells measure 7-17 $\mu \times$ 7-11 μ . No conceptacles observed.

REMARKS. This form strongly suggests *L. ovatum* but the material available for study is too limited to be certain.

SAMPLE NUMBER AND LOCALITY. S-10100, Melinau Gorge, north-east Sarawak.

AGE. Lower Oligocene (Tc).

Lithophyllum quadrangulum Lemoine

(Pl. 4, fig. 4)

- 1934 *Lithophyllum quadrangulum* Lemoine : 279, text-fig. 10.
 1934 *Lithophyllum quadrangulum* Lemoine ; Lemoine & Mengaud : 178, text-fig. 4.

DESCRIPTION. Plant forms a very thin crust (175-220 μ thick), composed entirely of hypothallic tissue. Hypothallus coaxial but the curved layers of cells form only gentle arcs and they are almost vertical. Cells large, measuring 28-34 $\mu \times$ 13-17 μ .

REMARKS. This species has very characteristic features : (1) a thin crust consisting entirely or almost entirely of hypothallus ; (2) the unusual structure of the hypothallus ; and (3) the large cells. It has a long time range (Mid-Eocene to Mid-Miocene), and apparently became widely distributed geographically.

SAMPLE NUMBER AND LOCALITY. S-10160, Melinau Gorge, north-east Sarawak.

AGE. Middle Oligocene (Td).

Lithoporella melobesioides (Foslie)

(Pl. 2, fig. 6)

- 1904 *Mastophora* (*Lithoporella*) *melobesioides* Foslie ; Weber van Bosse & Foslie : 73-77, text-figs. 30-32.
 1939 *Melobesia* (*Lithoporella*) *melobesioides* Foslie ; Lemoine : 108-110, text-figs. 78, 79.
 1943 *Lithoporella melobesioides* (Foslie) ; Lignac-Grutterink : 292-293, pl. 2, fig. 8.
 1949 *Lithoporella* (*Melobesia*) *melobesioides* (Foslie) Johnson & Ferris : 196-197, pl. 37, figs. 4, 5 ; pl. 39, fig. 2.
 1950 *Lithoporella melobesioides* (Foslie) ; Johnson & Ferris : 18, pl. 8, fig. A.
 1957 *Lithoporella melobesioides* (Foslie) ; Johnson : 234, pl. 37, fig. 5 ; pl. 43, figs. 1, 2 ; pl. 49, fig. 4 ; pl. 56, fig. 6.

DESCRIPTION. Thallus consists of a single layer of large cells except around the conceptacles. Cells elongated vertically and commonly slightly obliquely. Cells range greatly in size even in a single slice across a thallus. Range of cell size of 17 specimens measured was 26-82 μ high and 12-35 μ wide.

REMARKS. This is probably the most common species of coralline algae observed in the Borneo collections. Fragments occur on many slides. The cell dimensions all fit within those of the highly variable, widespread, long ranged *L. melobesioides*.

SAMPLE NUMBER AND LOCALITY. S-7063, south-west end of Batu Asi limestone, Upper Baram River, Sarawak.

AGE. Paleocene.

TABLE 2.—*Lithoporella melobesioides* (Foslie)
Cell Size of Typical Specimens (in μ)

Slide	Cell dimensions	Age
S-7063e	48-75 \times 21-26	Paleocene
S-7063g	49-70 \times 29-35	Paleocene
S-6175a	45-82 \times 24-33	Paleocene
S-7063h	66-70 \times 16-19	Paleocene
S-7063m	56-73 \times 30-48	Paleocene
S-7077e	26-39 \times 14-18	Paleocene
S-6175a	41-53 \times 17-24	Paleocene
BM. 13	30-48 \times 14-22	Paleocene
S-10153c	30-51 \times 14-29	Middle Oligocene
S-10176b	28-43 \times 22-30	Lower Miocene
S-7111i	27-40 \times 17-21	Lower Miocene

Lithoporella antiquitas Johnson

(Pl. 6, fig. 3)

1961 *Lithoporella antiquitas* Johnson : 937, pl. 276, figs. 1, 2.

DESCRIPTION. Thallus very small, encrusting, consisting of a single layer of vertically elongated cells, 44-53 μ long and 14-17 μ wide. Conceptacle small, 341 μ in diameter and 128 μ high.

REMARKS. Closely resembles the holotype from the Miocene of Eniwetok, Marshall Islands, except for a slightly larger conceptacle.

SAMPLE NUMBER AND LOCALITY. S-7081, Belukan River, Sarawak.

AGE. Lower Miocene (Te).

Lithoporella cf. *minus* Johnson

(Pl. 3, fig. 5)

1964 *Lithoporella minus* Johnson : Cro, pl. 2, fig. 6.

DESCRIPTION. Thallus tiny, irregular crustose, consisting of a single layer of cells except around the conceptacle. Cells 8-20 μ high, and 11-18 μ wide. Conceptacle 373 $\mu \times$ 200 μ , with a single large pore.

REMARKS. Only one specimen observed in the Paleocene collection. It closely resembles the holotype from the Eocene of Ishigaki Ryukyu Islands, except for slightly shorter cells.

SAMPLE NUMBER AND LOCALITY. S-7077, Upper Baram River, Sarawak.

AGE. Paleocene.

Melobesia cf. *cuboides* Johnson

- 1957 *Melobesia* ? *cuboides* Johnson : 234, pl. 43, figs. 6, 7.
 1962 *Melobesia cuboides* Johnson ; Johnson : 164, pl. 5, fig. 6.

DESCRIPTION. Thallus monostromatic. Cells cubic or horizontally elongated with thick walls. Cell size $15-34 \mu \times 12-21 \mu$.

REMARKS. Similar to material previously described by Johnson (1962) from Batu Gading, Sarawak.

SAMPLE NUMBER AND LOCALITY. S-6623, south-west end of Melinau limestone, S-10176, Melinau Gorge, north-east Sarawak.

AGE. Lower Miocene (Lower Te).

Dermatolithon saipanense Johnson

(Pl. 6, fig. 4)

- 1957 *Dermatolithon saipanense* Johnson : 235, pl. 57, figs. 4, 6.

DESCRIPTION. Thallus forms a thin crust. Hypothallus of one or two layers of elongated cells $32-46 \mu$ high and $14-21 \mu$ wide. Perithallus of square or vertically elongated cells, $30-33 \mu$ long and $24-32 \mu$ wide.

REMARKS. The one Borneo specimen observed has cells within the size range of this species, although the average cell size is a little smaller than that of the Saipan material.

SAMPLE NUMBER AND LOCALITY. S-7111, Belukan River, Sarawak.

AGE. Lower Miocene (Lower Te).

THAUMATOPORELLA Pia 1927*Thaumatoporella parvovesiculifera* (Raineri)

(Pl. 6, fig. 6)

- 1922 *Gyroporella parvovesiculifera* Raineri : 83, pl. 13, figs. 17, 18.
 1927 *Thaumatoporella parvovesiculifera* (Raineri) Pia : 69.
 1938 *Thaumatoporella parvovesiculifera* (Raineri) ; Pia : 491, pl. 1, figs. 1-5 ; pl. 2, figs. 6-14.
 1956 *Lithoporella melobesioides* (Foslie) ; Elliott : 327, pl. 2, figs. 8, 9.
 1957 *Polygonella incrustata* Elliott : 230, pl. 1, figs. 11, 12.
 1957 *Lithoporella elliotti* Emberger : 625, pl. 32, figs. 1-4.
 1959 *Thaumatoporella* cf. *parvovesiculifera* (Raineri) ; Gasche, pl. 1, fig. 3.
 1959 *Thaumatoporella parvovesiculifera* (Raineri) ; Sartoni & Crescenti : 129, pl. 2, figs. 1-5.
 1960 *Thaumatoporella parvovesiculifera* (Raineri) ; Radoicic : 133, pls. 1, 2.

DESCRIPTION. Thallus consists of a single layer of long cells, polygonal in cross-section. Cells $34-91 \mu$ long, and $16-22 \mu$ wide.

REMARKS. Grows encrusting a shell or other hard object. Closely resembles Elliott's (1957) late Jurassic-early Cretaceous material except in having slightly smaller cells ($34-91 \mu \times 16-22 \mu$ instead of $65-104 \mu \times 26-33 \mu$) and more undulating growth habit. Only a single specimen observed.

SAMPLE NUMBER AND LOCALITY. S-7063, south-west end of Batu Asi limestone, Upper Baram River, Sarawak.

AGE. Paleocene.

Subfamily **CORALLINOIDEAE** (Articulated Corallines)

Genus *CORALLINA* Linnaeus 1758

Corallina sp. *A*.

DESCRIPTION. Segments small, 0.8–1.3 mm. long and 0.16–0.25 mm. wide, 14 to 18 tiers of cells to a segment. Cells at centre of tiers 47–64 μ long and 6–12 μ wide. Marginal cells 22–35 μ long and 6–14 μ wide.

REMARKS. Only a few worn segments of *Corallina* were observed in the Paleocene collection. Data from the two best specimens are given above. They closely resemble *Corallina* sp. *l*. (Segonzac 1961 : 444).

SAMPLE NUMBER AND LOCALITY. S-7063, south-west end of Batu Asi limestone, Upper Baram River, Sarawak.

AGE. Paleocene.

Corallina cf. *abundans* Lemoine

(Pl. 3, figs. 6, 7)

1934 *Corallina abundans* Lemoine : 284–285, text-fig. 16.

DESCRIPTION. Segments 0.14–0.22 mm. wide. Cells of medullary hypothallus at middle, 52–64 μ long and 7–12 μ wide. Marginal cells 13–14 $\mu \times$ 8–11 μ wide.

A fragment of *Corallina* with a conceptacle chamber occurs on the same slide and probably represents the same species. The conceptacle space is rounded conical, 218 μ wide near base and 356 μ high.

REMARKS. Represented by only a few frayed fragments from a single locality. Their cells, both medullary and marginal, agree in length with Lemoine's species but are much narrower (hypothallus 7–12 μ versus 8–20 μ , perithallus 8–11 μ versus 15–25 μ).

SAMPLE NUMBER AND LOCALITY. S-6610, south-west end of Melinau limestone, Sarawak.

AGE. Lower Oligocene (Tc).

Corallina neuschelorum Johnson

(Pl. 5, fig. 4)

1957 *Corallina neuschelorum* Johnson : 239, pl. 37, fig. 3 ; pl. 50, figs. 1–4.

DESCRIPTION. Segments flattened, mainly hypothallic tissue, with cells in centre of layers 48–76 μ long and 9–15 μ wide. Marginal cells 19–27 $\mu \times$ 8–16 μ .

REMARKS. The cell dimensions closely fit those of the Saipan species, although the marginal cells are somewhat longer (19–27 μ versus 15–21 μ).

SAMPLE NUMBER AND LOCALITY. S-7111, Belukan River, Sarawak.

AGE. Lower Miocene (Lower Te).

Corallina cf. *prisca* Johnson

1957 *Corallina prisca* Johnson : 239, pl. 37, fig. 4 ; pl. 44, figs. 1, 2, 7-11.

DESCRIPTION. Pieces of segments about 0.35 mm. wide. Cells at centre of medullary tissue 63-88 μ long and 7-8 μ wide. Node between two segments 201 μ long.

REMARKS. The dimensional data for these fragments is within the range of *Corallina prisca* from the Upper Eocene of Saipan.

SAMPLE NUMBER AND LOCALITY. S-10025 (Tb) and S-10153 (Td), both from north face of Melinau Gorge, Sarawak.

AGE. Upper Eocene (Tb) and Middle Oligocene (Td).

Jania miocenica Johnson

(Pl. 5, fig. 3)

1961 *Jania miocenica* Johnson : 938-939, pl. 278, figs. 6-8.

DESCRIPTION. Slender segments with dimensional data tabulated below.

TABLE 3.—*Jania miocenica* (Dimensions in μ)

Slide number	Number cells in row	Hypothallic Cells		Perithallic Cells		Age
		Length	Width	Length	Width	
S-6921d	19	33-39	13-17	15-26	14-24	Lower Oligocene
S-6921d	17-19	35-46	12-18	14-30	9-21	Lower Oligocene
S-6921d	27-32	36-50	14-20	13-28	16-21	Lower Oligocene
S-7111d	22	33-40	14-22	11-21	11-18	Lower Miocene

REMARKS. In general appearance and dimensional data, the Borneo specimens agree exactly with those described by Johnson (1961) from the Lower Miocene of Eniwetok.

SAMPLE NUMBER AND LOCALITY. S-6921 (Tc), mouth of Tukuruk River, Melinau, Sarawak. S-7111 (Te), Belukan River, Sarawak.

AGE. Lower Oligocene (Tc) and Lower Miocene (Lower Te).

Jania cf. *nummulitica* Lemoine

(Pl. 6, fig. 5)

1934 *Jania nummulitica* Lemoine : 285.

DESCRIPTION. Piece of a segment 2.12 mm. long and 0.33 mm. wide. It contains 35 layers of cells, with approximately 18 cells in a row as cut by the section studied. The cells at the centre of the rows measure 63-76 μ high and 11-18 μ wide. The marginal cells are 25-30 μ high and 16-21 μ wide.

REMARKS. Represented by a couple of fragments. The largest is described above. The cell dimensions are close to those of *J. nummulitica* Lemoine from the Upper Eocene of Hungary. However, the cells of the Borneo specimens are slightly shorter and wider than the holotype.

SAMPLE NUMBER AND LOCALITY. S-6921, mouth of Tukuruk River, Melinau, Sarawak.

AGE. Lower Oligocene (Tc).

Jania vetus Johnson

(Pl. 4, fig. 2)

1957 *Jania vetus* Johnson : 237, pl. 52, fig. 2.

1961 *Jania vetus* Johnson ; Johnson : 939.

DESCRIPTION. Long, sometimes branching segments 0.26 to 0.48 mm. wide. Medullary cells from near centre measure 50-77 μ long and 15-26 μ wide. Marginal cells 13-16 $\mu \times$ 26-46 μ .

REMARKS. The cell sizes are within the ranges of the species described from the Miocene of Saipan.

SAMPLE NUMBER AND LOCALITY. S-7111, Belukan River, Sarawak.

AGE. Lower Miocene (Lower Te).

Amphiroa cf. *fortis* Johnson

(Pl. 6, fig. 7)

1961 *Amphiroa fortis* Johnson : 939, pl. 277, figs. 8, 9.

DESCRIPTION. Segments probably long, with diameters ranging from 0.7 to 0.9 mm., commonly 0.8 to 0.87 mm. Medullary hypothallus of layers of cells. The cells at the centre measure 42-79 μ long and 9-30 μ wide. There is a suggestion of alternating layers of long and short cells, but the difference in length is slight, 62-79 μ versus 49-64 μ . Marginal perithallic cells 15-29 $\mu \times$ 12-26 μ .

REMARKS. This form is very close to *Amphiroa fortis* Johnson from the late Eocene of Eniwetok. The Borneo specimens have cells about the same length but wider, 9-30 μ versus 6-11 μ in the hypothallus, and 12-22 μ versus 7-11 μ in the perithallus.

SAMPLE NUMBER AND LOCALITY. S-7073, Upper Baram River, Sarawak.

AGE. Paleocene.

Amphiroa sp.

DESCRIPTION. Segments around 0.3 mm. wide. Medullary tissue shows an alternation of layers of long and short cells, formula 1-long, 1-short. Cells at centre of medullary area measure: long 42-56 $\mu \times$ 7-8 μ , short 34-40 $\mu \times$ 7-8 μ .

REMARKS. Represented by a few fragments.

SAMPLE NUMBER AND LOCALITY. S-10055, Melinau Gorge, Sarawak.

AGE. Upper Eocene (Tb).

Subterraniophyllum thomasi Elliott

(Pl. 6, figs. 1, 2)

1957b *Subterraniophyllum thomasi* Elliott : 73-74, pl. 13, figs. 1-9.

DESCRIPTION. Segments composed of wide medullary hypothallus and very narrow marginal perithallus. Hypothallus composed of slightly curved layers of large irregular cells. Cell layers shaped much the same as in *Amphiroa* with flattened top and sharply inclined margins. Cells irregular to almost regular in vertical section; very irregular, rounded to polygonal in horizontal section. Cells 85-118 μ long and 58-99 μ wide. Marginal perithallus thin, cells rectangular, 15-26 $\mu \times 7-21 \mu$.

REMARKS. In sections the medullary hypothallus appears light while the perithallic tissue is unusually dark, practically black. The Borneo material consists of fragments of segments. They fit Elliott's description of the type material from Iraq except that the perithallic cells are slightly larger.

SAMPLE NUMBER AND LOCALITY. S-6921, mouth of Tukuruk River, Melinau, Sarawak.

AGE. Lower Oligocene (Tc).

Genus *DISTICHOPLAX* Pia 1934*Distichoplax biserialis* (Dietrich)

(Pl. 5, fig. 7)

1918 *Lithothamnium* ? sp., Trauth : 220, pl. 11, figs. 2, 3.1918 *Lithothamnium nummuliticum* Trauth : 219, pl. 11, fig. 1.1927 *Lithothamnium biseriale* Dietrich : 461, pl. 11, fig. 1.1930 *Lithoporella* Pia : 133.1934 *Distichoplax biserialis* (Dietrich) Pia : 15, text-figs. 5-8.1956b *Distichoplax biserialis* (Dietrich) ; Elliott : 332, pl. 11, fig. 1.1958 *Distichoplax biserialis* (Dietrich) ; Lemoine : 2145.1960 *Distichoplax biserialis* (Dietrich) ; Elliott : 226, pl. 8, figs. 2, 3.1961 *Distichoplax biserialis* (Dietrich) ; Segonzac : 446, pl. 13, figs. 3, 4.1963 *Distichoplax biserialis* (Dietrich) ; Keij : 153-160, pl. 1.

DESCRIPTION. The thallus develops as small undulating plaque or sheet. They may occur singly or a number may grow in close association. Commonly each one will be oriented somewhat differently. Sections cutting the thallus at different angles look very differently. The most characteristic is a transverse section cut parallel to the length of the cells. This gives the "fishbone fossil" with two rows of obliquely elongated cells coming together at a wide angle (Pl. 5, fig. 7). In the specimen illustrated, the cells have lengths of 76-81 μ and widths of 30-41 μ .

REMARKS. This is a very widespread Paleocene and early Eocene fossil, with its greater development in the Paleocene.

SAMPLE NUMBER AND LOCALITY. BM13, Batu Asi limestone, Upper Baram area, Sarawak.

AGE. Paleocene.

Family **SOLENOPORACEAE**Genus **SOLENOMERIS** Douvillé*"Solenomeris"* sp.

(Pl. 5, fig. 1)

DESCRIPTION. Thallus forms rounded masses from which branches or irregular protuberances may develop. The fragments observed in the Borneo collection consisted of perithallic tissue. This is composed of threads of coarse semirectangular cells, regularly arranged. The walls of the cell threads are quite thick. The cross partitions between the cells are thinner. They develop at approximately the same levels in adjoining threads, giving the tissue an articulated or layered appearance in vertical sections. Cells measure $21-33\ \mu$ high and $41-65\ \mu$ wide.

REMARKS. This is one of the characteristic Paleocene fossils. It occurs in beds of about Danian age from Morocco to the East Indies and in Guatemala and Cuba. [Since this paper was submitted, Professor Johnson has pointed out that *Solenomeris* may be a hydrozoan, in which case he thinks that the present species should be referred to *Parachaetetes*. Ed.]

SAMPLE NUMBER AND LOCALITY. B.M. 47, south-west end of Batu Asi limestone, Upper Baram River, Sarawak.

AGE. Paleocene.

Family **SIPHONOCCLADACEAE** Schmitz 1879Genus **PYCNOPORIDIUM** Yabe & Toyama 1928*Pycnoporidium sinuosum* Johnson & Konishi

(Pl. 5, fig. 2)

1960 *Pycnoporidium sinuosum* Johnson & Konishi : 1100-1101, pl. 134, figs. 1-4.

DESCRIPTION. Thallus consists of an irregular mass of loosely interwoven, coarse, sinuous, filaments. These filaments are $41-58\ \mu$ in diameter. They are partitioned by cross walls (septa) at irregular intervals ($47\ \mu$ to $72\ \mu$). Second branching occurs sparsely at irregular intervals. The filaments have thick walls with occasional uncalcified chambers occupying the spaces within the tubes between the septa.

REMARKS. This species was originally described from the late Cretaceous of Guatemala. It differs from the only previously described Paleocene species from Iraq, *P. levantian* Johnson, in having slightly smaller tubes and more closely spaced septa. Represented by only a few specimens in the Borneo collection.

SAMPLE NUMBER AND LOCALITY. S-7077, Upper Baram River, Sarawak.

AGE. Paleocene.

V. REFERENCES

- ADAMS, C. G. 1965. The Foraminifera and Stratigraphy of the Melinau limestone, Sarawak, and its importance in Tertiary correlation. *Quart. J. Geol. Soc. Lond.* (in press).
- AIROLDI, M. 1932. Contributo allo studio delle Corallinacee dell terziario Italiano. Part 1. Corallinacee dell' Oligocene ligure-piemontese. *Palaeontogr. ital.*, Pisa (n.s., 3) **33**: 58-83, pls. 9-12. (1933).
- CAPEDER, G. 1900. Contribuzione allo studio dei *Lithothamnion* terziari. *Malpighia*, Genova, **14**: 172-182, pl. 6.
- DIETRICH, W. O. 1927. In Sven Hedin. *Eine Routenaufnahme durch Ostpersien II*, 3: 459, pl. 2, fig. 1.
- ELLIOTT, G. F. 1956. Fossil calcareous algae from the Middle East. *Micropaleontology*, New York, **1-2**: 125-131, pl. 1.
- 1956b. Further records of fossil calcareous algae from the Middle East. *Micropaleontology*, New York, **2**: 327-334, pl. 2, fig. 1.
- 1957. New calcareous algae from the Arabian Peninsula. *Micropaleontology*, New York, **3**: 227-230.
- 1957b. *Subterraneanophyllum*, a new Tertiary calcareous alga. *Palaeontology*, London, **1**: 73-75, pl. 13.
- 1960. Fossil calcareous algal floras of the Middle East, with a note on a Cretaceous problematicum, *Hensonella cylindrica*, gen. et sp. nov. *Quart. J. Geol. Soc. Lond.*, **115**: 217-233, pl. 8.
- GASCHE, E. 1959. In Raffi, G. & Forti, A. Micropaleontological and stratigraphical investigations in Montagna del Morrone (Abruzzi, Italy). *Rev. Micropal.*, Paris, **2**: 8-20, pls. 1, 2.
- HAILE, N. S. 1962. The Geology and Mineral Resources of the Suai-Baram Area, North Sarawak. *Mem. Brit. Borneo Geol. Surv.*, **13**: 176 pp.
- HOWE, M. A. 1918. On some fossil and Recent Lithothamnieae of the Panama Canal Zone. *Bull. U.S. Nat. Mus.*, Washington, **103**: 1-13, pls. 1-11.
- JOHNSON, J. H. 1957. Geology of Saipan, Mariana Islands; Calcareous algae. *Prof. Pap. U.S. Geol. Surv.*, Washington, **280-E**: 209-243, pls. 37-60.
- 1961. Fossil algae from Eniwetok, Funafuti, and Kita-Daito-Jima. *Prof. Pap. U.S. Geol. Surv.*, Washington, **260**: 907-947, pls. 267-280.
- 1962. Calcareous algae from Sarawak. *Mem. Brit. Borneo Geol. Surv.*, **13**: 151-168, pls. 1-5.
- 1964. Paleocene calcareous red algae from northern Iraq. *Micropaleontology*, New York, **10**: 207-216, pls. 1-3.
- 1964. Fossil algae, Ishigaki, Ryukyu Islands. *Prof. Pap. U.S. Geol. Surv.*, Washington, **399C**: 1-13, pls. 1-7.
- JOHNSON, J. H. & FERRIS, B. J. 1949. Tertiary coralline algae from the Dutch East Indies. *J. Paleont.*, Chicago, **23**: 193-198, pls. 37-39.
- 1950. Tertiary and Pleistocene coralline algae from Lau, Fiji. *Bull. Bishop Mus. Honolulu*, **201**: 1-27, pls. 1-9.
- JOHNSON, J. H. & KONISHI, K. 1960. An interesting late Cretaceous calcareous alga from Guatemala. *J. Paleont.*, Chicago, **34**: 1099-1105, pl. 134.
- KEIJ, A. J. 1963. *Distichoplax* in Sarawak and North Borneo. *Bull. Brit. Borneo Geol. Surv.*, **4**: 153-160, pl. 1.
- LEMOINE, MME PAUL. 1926. Revision des Mélobésiées tertiaires d'Italie décrites par M. Capeder. *C.R. Socs. sav. Paris & Dép.*, **1925**: 241-259, 17 figs.
- 1928. Corallinacées fossiles de Catalogne et de Valence recueillies par M. l'Abbé Bataller. *Bull. Inst. catal. Hist. nat. Lérida* (2) **8**, 5-6: 92-107, 20 figs.
- 1930. Les Mélobésiées recueillies par M. Viennot dans le Miocène de la Province de Grenade. *Bull. Soc. géol. Fr.*, Paris (4) **29**: 263-272, pl. 24.
- 1934. Algues calcaires de la famille des Corallinacées recueillies dans les Carpathes occidentales par M. Andrusov. *Věstn. geol. Úst. čsl. Rep.*, Praha, **9**, 5: 269-289, 16 figs.

- LEMOINE, MME PAUL 1939. Les algues calcaires fossiles de L'Algérie. *Bull. Cartogéol. Algér.* (1) **9** : 1-128, pls. 1-3.
- 1958. Sur l'attribution du *Distichoplax biserialis* (Dietrich) Pia aux pterobranches. *C.R. Acad. Sci. Paris*, **246** : 2145-2148.
- LEMOINE, MME PAUL & MENGAUD, M. L. 1934. Algues calcaires de l'Eocene de la Province de Santander (Espagne). *Bull., Soc. Hist. nat. Toulouse*, **46** : 171-180, 6 figs.
- LIECHTI, P., ROE, F. W. & HAILE, N. S. 1960. The Geology of Sarawak, Brunei and the western part of North Borneo. *Bull. Geol. Surv. Dept. Brit. Terr. Borneo*, **3**. 360 pp., 73 pls.
- LIGNAC-GRUTTERINK. 1943. Some Tertiary Corallinaceae of the Malaysian Archipelago. *Verh. geol.-mijnb. Genoot. Ned. Kolon., 's Gravenhage (Geol.)* **113** : 292-293, pl. 2, fig. 8.
- MASLOV, V. P. 1956. Fossil algae of the U.S.S.R. *Trav. Inst. Sci., Geol. Akad. Nauk. SSSR*, **160** : 1-301.
- MIRANDA, F. 1935. Algas coralineas fosiles del terciario de San Vicente de la Barquera (Santander). *Bol. Soc. esp. Hist. nat., Madrid*, **30** : 279-287.
- PFENDER, J. 1926. Sur les organismes du Nummulitique de la colline de San Salvador pres Camarasa Catalogne. *Bol. Soc. esp. Hist. nat., Madrid*, **26** : 321-330, pls. 8-15.
- PIA, J. 1927. Thallophyta. In Hirmer, M. *Handbuch der Paläobotanik*, **1** : 31-136.
- 1930. Neue Arbeiten über fossile Solenoporaceae und Corallinaceae. *Neues Jb. Miner., Stuttgart*, **3** : 122.
- 1934. Kalkalgen aus dem Felsen von Hričovské Podhradie im Waagtal. *Věst. geol. Úst. česl. Rep. Praha*, **10** : 14-18, figs. 5-8.
- 1938. Über *Thaumatoporella parvovesiculifera* Rain. spec. und ihr Auftreten auf der Insel Naxos. *Praktika Akad. Athen.*, **13** : 491-495, pls. 1, 2.
- RADOIČIČ, R. 1960. On the little known species *Thaumatoporella parvovesiculifera* (Rain.) *Bull. Serv. Geol. Geophys. Serbie, Beograd (A)* **18** : 133-140, pls. 1, 2.
- RAMA RAO & PIA, J. 1936. Fossil algae from the uppermost Cretaceous beds (Niniyur group) of the Trichinopoly district S. India. *Palaeont. indica, Calcutta*, **21**, 4 : 1-49, pls. 1-6.
- RAINERI, R. 1922. Alge siforee fossili della Libia. *Atti. Soc. ital. Sci. nat., Milano*, **61** : 72-86, pl. 3.
- 1923. Alge fossili mioceniche di Cirenaica. *Nuova Notarisia, Padova*, **35** : 5-23, 16 figs.
- ROTHPLETZ, A. 1891. Fossile Kalkalgen aus den Familien der Codiaceen und der Corallineen. *Z. dtsh. geol. Ges., Berlin*, **43** : 295-322, pls. 15-17.
- SARTONI, S. & CRESCENTI, U. 1959. La zona a *Palaeodasycladus mediterraneus* (Pia) nel Lias dell'Appennino meridionale. *Giorn. Geol., Bologna (2)* **27** : 115-139, pls. 1-3.
- SCHWAGER. 1883. Die Foraminiferen aus den Eocanablagerungen der libyischen Wüste und Aegyptens. *Palaeontographica, Stuttgart*, **30** : 79-154, pls. 24-29.
- SEGONZAC, G. 1961. Niveaux a' Algues dans le Thanetien des Pyrenées. *Bull. Soc. géol. Fr., Paris (7)* **3** : 437-448, text-plate.
- TRAUTH, F. 1918. Das Eozänvorkommen bei Radstadt im Pongau. *Denkschr. Akad. Wiss. Wien*, **95** : 171-278.
- WEBER VAN BOSSE & FOSLIE, M. H. 1904. Corallinaceae Siboga Expedition. *Siboga Exped., Leiden*, **61** : 1-110, pls. 1-16.

PLATE 1

(All $\times 50$)

FIG. 1. *Archaeolithothamnium lauensum* Johnson & Ferris. Vertical section of a fertile fragment. Lower Miocene. V.51758.

FIG. 2. *Archaeolithothamnium lugeoni* Pfender. A somewhat oblique section. Paleocene. V.51760.

FIGS. 3, 4. *Archaeolithothamnium aschersoni* (Schwager). 3, Vertical section of a thin crust. V.51762. 4, Oblique section of a small rounded knob. Paleocene. V.51761.

FIG. 5. *Archaeolithothamnium* cf. *cyrenaicum* Raineri. A slightly oblique section. Middle Oligocene. V.51759.

FIG. 6. *Archaeolithothamnium intermedium* Raineri. A nearly vertical section. Lower Miocene. V.51758.

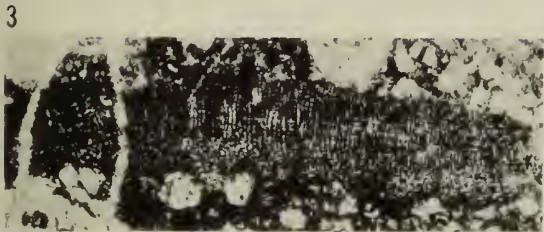
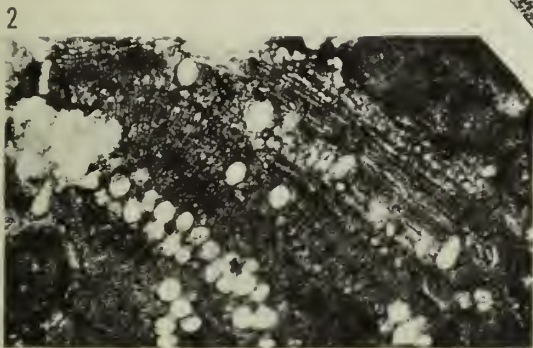
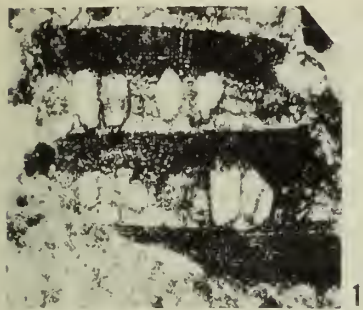


PLATE 2

(All $\times 50$)

FIG. 1. *Archaeolithothamnium saipanense* Johnson. Vertical section, Middle Oligocene. V.51763.

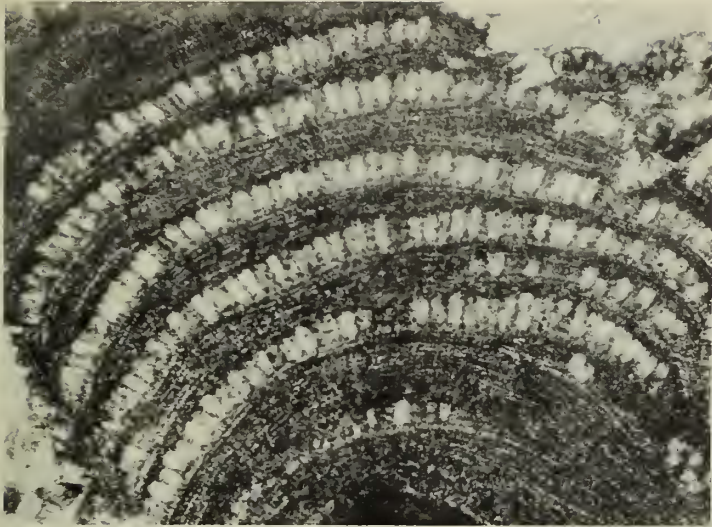
FIG. 2. *Lithothamnium cantabricum* Lemoine. Vertical section showing hypothallus and perithallus. Paleocene. V.51766.

FIG. 3. *Archaeolithothamnium sociabile* Lemoine. Nearly vertical section. Middle Oligocene. V.51764.

FIG. 4. *Lithothamnium* cf. *caucasicum* Maslov. Slightly oblique section of a small branch. Paleocene. V.51767.

FIG. 5. *Archaeolithothamnium sarawakense* n. sp. Holotype. Vertical section. Paleocene. V.51762.

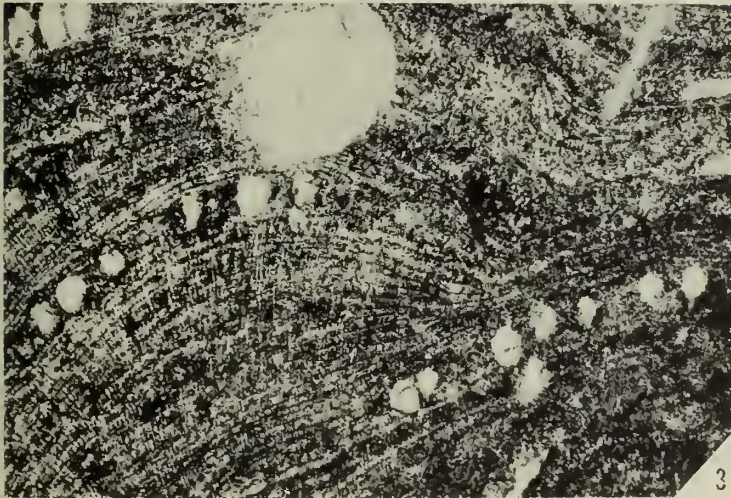
FIG. 6. *Lithoporella melobesioides* (Foslie). Paleocene. V.51766.



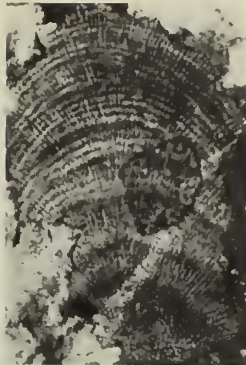
1



2



3



4



5



6

PLATE 3

(All $\times 50$)

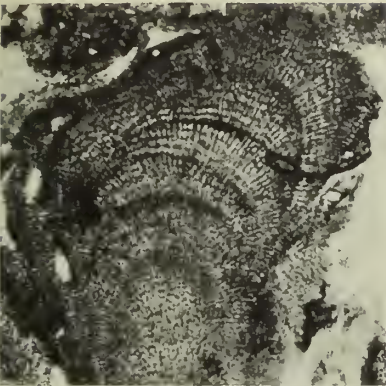
FIGS. 1, 2. *Mesophyllum* cf. *pfenderae* (Lemoine). Sections of small branches. Fig. 2 shows a conceptacle with sporangia. Paleocene. V.51768.

FIG. 3. *Mesophyllum curtum* Lemoine. Vertical section of a branch, badly recrystallized. Lower Miocene. V.51769.

FIG. 4. *Archaeolithothamnium macrosporangium* n. sp. Holotype. Vertical section showing tissue and sporangia. Lower Oligocene. V.51765.

FIG. 5. *Lithoporella* cf. *minus* Johnson. Badly recrystallized. A conceptacle chamber to right. Paleocene. V.51760.

FIGS. 6, 7. *Corallina* cf. *abundans* Lemoine. Fig. 6 shows a terminal conceptacle chamber. V.51778. Fig. 7, Fragment of a segment. Lower Oligocene. V.51779.



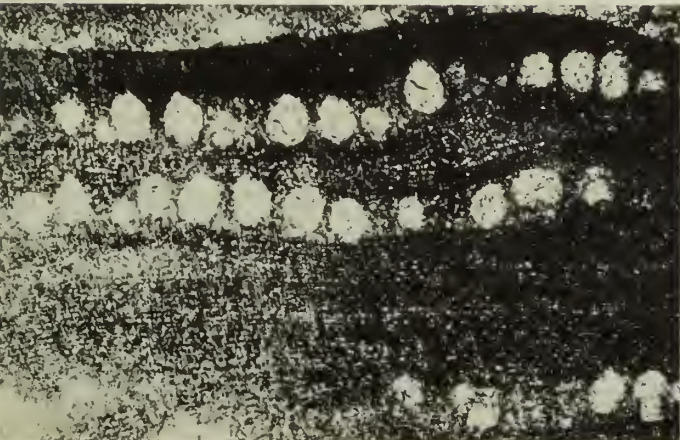
1



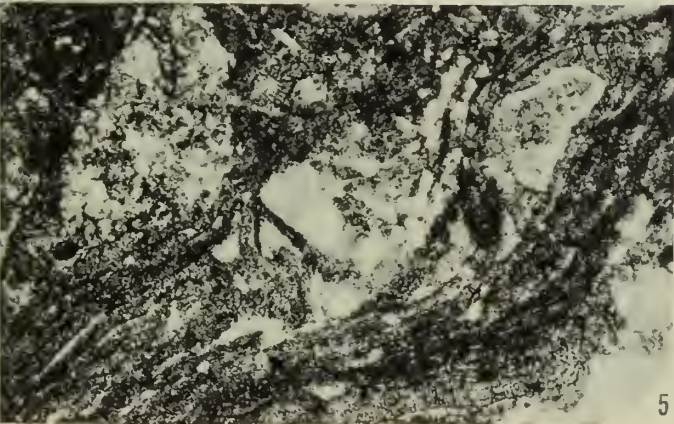
2



3



4



5



6



7

PLATE 4

(All $\times 50$)

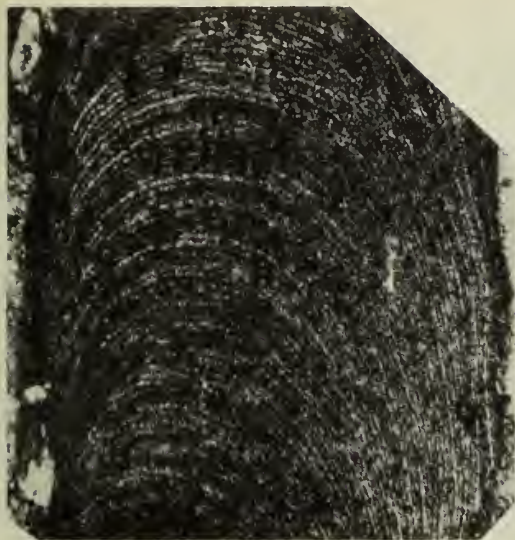
FIGS. 1, 6. *Mesophyllum vaughanii* (Howe) var. *sarawakense* nov. Fig. 1, A nearly vertical section, Holotype. Middle Oligocene. V.51772. Fig. 6, An oblique section. Middle Oligocene. V.51759.

FIG. 2. *Jania vetus* Johnson. Lower Miocene. V.51758.

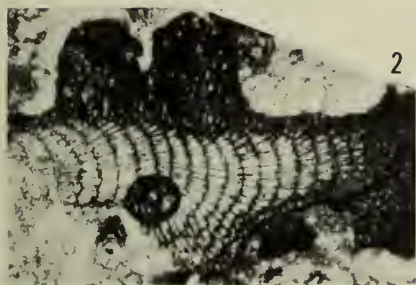
FIG. 3. *Mesophyllum vaughanii* (Howe). Lower Oligocene. V.51771.

FIG. 4. *Lithophyllum quadrangulum* Lemoine. Section of a long thin crust mainly hypothallus. Middle Oligocene. V.51774.

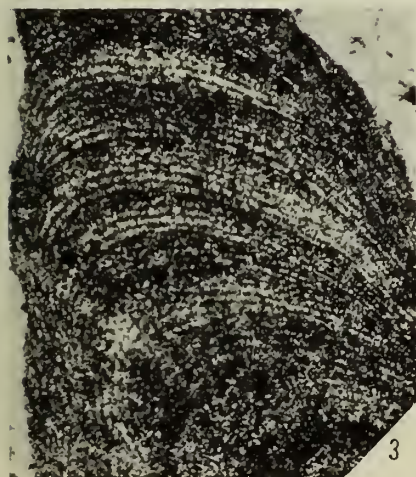
FIG. 5. *Lithophyllum* cf. *obliquum* Lemoine. Vertical section. Miocene. V.51773.



1



2



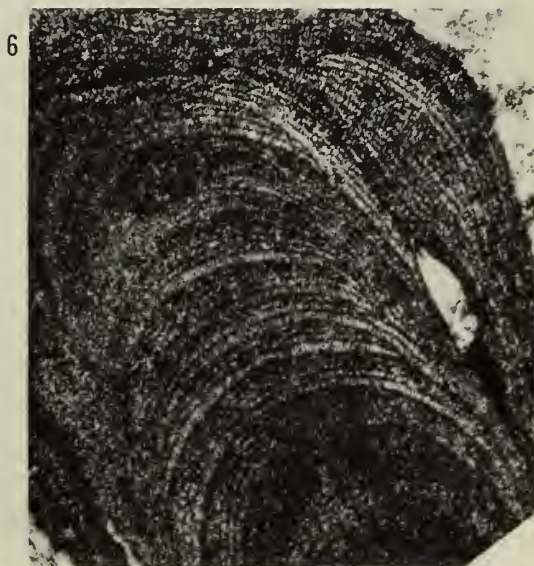
3



4



5



6

PLATE 5

- FIG. 1. "*Solenomeris*" sp. Vertical section of a fragment, $\times 40$. Paleocene. V.51784.
FIG. 2. *Pycnoporidium sinuosum* Johnson & Konishi ($\times 50$). Paleocene. V.51785.
FIG. 3. *Jania miocenica* Johnson ($\times 50$). Lower Miocene. V.51758.
FIG. 4. *Corallina neuschelorum* Johnson. A partial segment, $\times 50$. Lower Miocene. V.51758.
FIG. 5. *Mesophyllum vaughanii* (Howe). Fragment showing conceptacle chambers, $\times 50$. Lower Oligocene. V.51770.
FIG. 6. *Lithophyllum capederi* Lemoine. Several crusts, $\times 50$. Lower Miocene. V.51775.
FIG. 7. *Distichoplax biserialis* (Dietrich). Sections of two fragments, $\times 40$. Paleocene, Borneo. V.51783.
FIG. 8. *Lithophyllum densum* Lemoine. Slightly oblique long section of a branch, $\times 50$. Paleocene. V.51767.

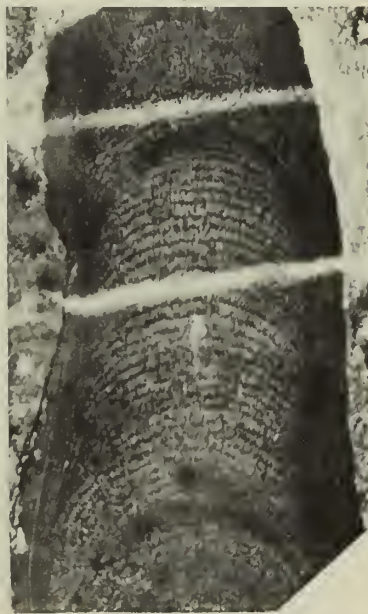
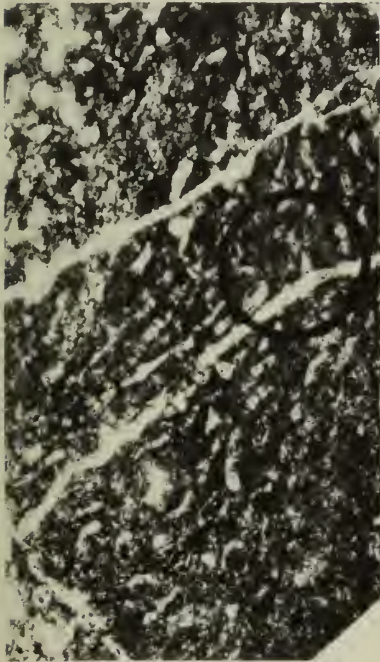
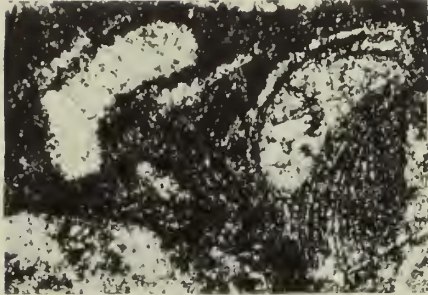


PLATE 6

(All $\times 50$)

FIGS. 1, 2. *Subterraniophyllum thomasi* Elliott. Fig. 1, An oblique long section. Lower Oligocene. V.51782. Fig. 2, Longitudinal section of a worn fragment. Lower Oligocene. V.51782.

FIG. 3. *Lithoporella antiquitas* Johnson. Two conceptacle chambers shown. Lower Miocene. V.51776.

FIG. 4. *Dermatolithon saipanense* Johnson. Lower Miocene. V.51758.

FIG. 5. *Jania* cf. *nummulitica* Lemoine. Lower Oligocene. V.51780.

FIG. 6. *Thaumatoporella parvovesiculifera* (Raineri). Paleocene. V.51777.

FIG. 7. *Amphiroa* cf. *fortis* Johnson. Slightly oblique vertical section. Paleocene. V.51781.

